

## System for Anomaly and Failure Detection

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Since ground testing of the space shuttle main engine began in 1975, there have been 28 major incidents. These failures—most of which were during the early phases of development when significant design changes were still taking place—occurred despite an extensive internal system of self-checking and measurement redlines. This number almost seems insignificant when compared to the more than 1,500 tests without major incidents. However, these failures have costs (engine damage, stand damage, etc.) associated with them that belie their small numbers.

Development of the System for Anomaly and Failure Detection was initiated in 1985 and completed in 1994. It has been tested (297 tests to date) using data from actual tests ranging from those that did not have shutdowns or severe damage to those with catastrophic failures (17 tests). Data from existing engine computer models were used to test against failure modes for which no hot-fire data existed.

In all tests in which significant failures occurred, the algorithm has shown improvement over redline methodology by issuing earlier shutdown commands, with the exception of the few catastrophic failures that occurred within a few milliseconds and with no prior warning. The system has also demonstrated that no inadvertent

shutdown commands would have been issued. A conservative analysis of the savings that could have been accrued had the system been active during the 17 tests resulting in catastrophic failures indicates a potential savings of approximately \$48,000,000.

The algorithm has monitored 32 hot-fire tests on the Technology Test-Bed stand and was an active participant in the last test, which means that the detection system had shutdown authority if an incipient engine failure had been detected. These tests have included a standard all-Rocketdyne engine, a wide-throat engine with Rocketdyne pumps, and several with a wide-throat engine and a mix of Rocketdyne and Pratt & Whitney high-pressure pumps.

The System for Anomaly and Failure Detection system installed on the Technology Test-Bed stand is expected to be moved to Stennis Space Center late in 1995, where it will be used as a stand protection system.

Fox, T.; Cikanek, H.; and Evatt, T.  
May 18, 1994. Development of the System for Anomaly and Failure Detection. Advanced Earth-to-Orbit Propulsion Technology Conference, NASA/MSFC, Alabama.

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